

United States Patent Office

3,251,916

Patented May 17, 1966

1

3,251,916

CELLULAR MATERIALS COMPRISING EXPANDED POLYSTYRENE AND POLYURETHANE BINDER

John Leathem Matthew Newnham, York, Peter Merri-
man, Birmingham, and Donald James Simcox, Sutton
Coldfield, England, assignors to Dunlop Rubber Com-
pany Limited, London, England, a British company
No Drawing. Filed Dec. 20, 1962, Ser. No. 245,995
Claims priority, application Great Britain, Dec. 27, 1961,
46,242/61

5 Claims. (Cl. 264—128)

This invention relates to substantially rigid cellular materials, including substantially rigid cellular materials suitable for use in the in-situ preparation of mouldings and laminates for application to structural surfaces, for use as "crash padding" in vehicles and aircraft, and for protective packaging.

According to the present invention, a substantially rigid cellular material comprises bodies of an expanded polystyrene composition bonded together by means of a substantially non-cellular bonding agent.

The invention also includes a method of making a substantially rigid cellular material in which bodies of an expandable polystyrene composition are expanded and are subsequently bonded together by means of a substantially non-cellular bonding agent.

We prefer that the setting of the bonding agent used should be sufficiently slow to allow preferential accumulation of bonding agent at the points of contact of the expanded polystyrene composition bodies. This preferential accumulation is in our experience a desirable contribution to the strength of the finished product, especially if only a small proportion of bonding agent is used. Partly because they make possible the preferential accumulation just mentioned, and partly on account of other properties (referred to below), polyurethane bonding agents have shown themselves in our experience to be of outstanding value for bonding the polystyrene bodies.

Preferably, therefore, a substantially non-foaming liquid polyurethane-forming composition is used to afford the bonding agent. Such a liquid composition may suitably be derived from one or more organic compounds having at least two —NCX radicals in the molecule where X may in the case of each radical be an oxygen atom or a sulphur atom (e.g. a tolylene diisocyanate or a diphenylmethane diisocyanate or homologue thereof), and one or more organic chain compounds having at least two active-hydrogen-containing groups in the molecule; one or more catalysts (e.g. stannous octoate) and/or cross-linking agents may also be used to prepare the composition. The organic chain compounds just mentioned should be liquid or capable of giving liquid compositions with the other ingredients; some examples of suitable chemical types of organic chain compounds are polyether diols, triols and tetrols and sulphur analogues of those compounds, polyesters, polyesteramides, hydrocarbon polymers modified by the introduction of active-hydrogen-containing groups, and certain vegetable oils containing glycerides of hydroxy-acids (e.g. castor oil). The liquid polyurethane-forming composition may be formulated to contain a stoichiometric excess of —NCX radicals over the active-hydrogen-containing groups, and in this case it may if desired be caused or allowed to undergo a substantial degree of reaction before application to the expanded polystyrene composition bodies (provided that it still remains liquid), cross-linking and hardening by reaction with atmospheric moisture being allowed to take place after application. Instead, however, the liquid polyurethane-forming composition may be formulated to set and harden on its own, or by atmos-

2

pheric oxidation; in those cases, there may in appropriate formulations be less than the stoichiometric proportion of —NCX radicals, and costs and toxic hazards can then be somewhat reduced (as well as dependence upon atmospheric humidity). Ratios of —NCX radicals to active hydrogen atoms which are in the neighborhood of 1:1 generally give particularly rapid setting of the bonding agent, though even with a large excess of isocyanate (e.g. with a ratio of 5:1) rapid setting can still be secured by the use of a catalyst.

Some examples of substantially non-cellular bonding agents which may be used, other than the polyurethane compositions, are drying oils, varnishes and rubber latex gels. If a rubber latex binder is used, it need not be derived from a natural rubber latex, but may for example comprise a terpolymer of butadiene, acrylonitrile and methacrylic acid. Some further examples of the non-polyurethane bonding agents which may be used are plaster (plaster of Paris) and hydraulic cement (e.g. Portland cement) with or without sand or other aggregate.

A combination of bonding agents, applied successively, may be used if desired (e.g. as described in Examples XVIII, XX, XXII, XXIV and XXV below). Thus a material pre-bonded with a polyurethane bonding agent may be subsequently treated with a latex binder, with a liquid mixture comprising plaster and water or comprising a hydraulic cement and water, with a liquid polyurethane rubber, or with another secondary bonding agent.

The bodies of an expanded polystyrene composition may suitably be derived from bodies of a thermally-expandable polystyrene composition containing (in addition to polystyrene) a volatile liquid such as a mixture of pentanes, for example; the latter bodies may suitably be heated to 100° C., or a temperature of that order, to effect expansion. Generally it is convenient to use expanded polystyrene composition bodies with diameters of 0.1 mm. to 10 mm. or more. The expanded polystyrene composition bodies may be of any of a wide variety of shapes, and may thus be of an elongated shape or even of a fibrillar form. The ratio by weight of the expanded bodies to the bonding agent is normally within the range 7:1 to 1:10 (respectively) but is preferably within the range 3:1 to 1:5 (respectively); as the ratio just specified decreases, the strength and also the density of the product naturally increase, as does the drainage of excess bonding agent to the supporting surface (such drainage being useful when a particularly strong bond to a substrate is required). The expanded polystyrene composition bodies may generally be intimately stirred with the bonding agent in any suitable type of mixer, from which is should be transferred to the mould, cavity, surface or the like for which it is intended, well before any substantial setting and hardening of the bonding agent has taken place. The time required for setting and hardening may vary, even with the preferred polyurethane compositions, from a few minutes to several hours, according to the formulation of the bonding agent and its temperature.

When the liquid polyurethane-forming composition is used as the bonding agent, the expanded polystyrene composition bodies may if desired be moistened beforehand with water (assuming it is one of the ingredients), or treated beforehand with some other ingredient, with a view to obtaining quicker bonding. In this case, however, any carbon dioxide evolved by the reaction of —NCO radicals with water must be able to diffuse away without producing gas bubbles within the polyurethane component.

Cellular materials according to the present invention are relatively cheap (generally cheaper than rigid poly-